Saskatchewan
Industry and
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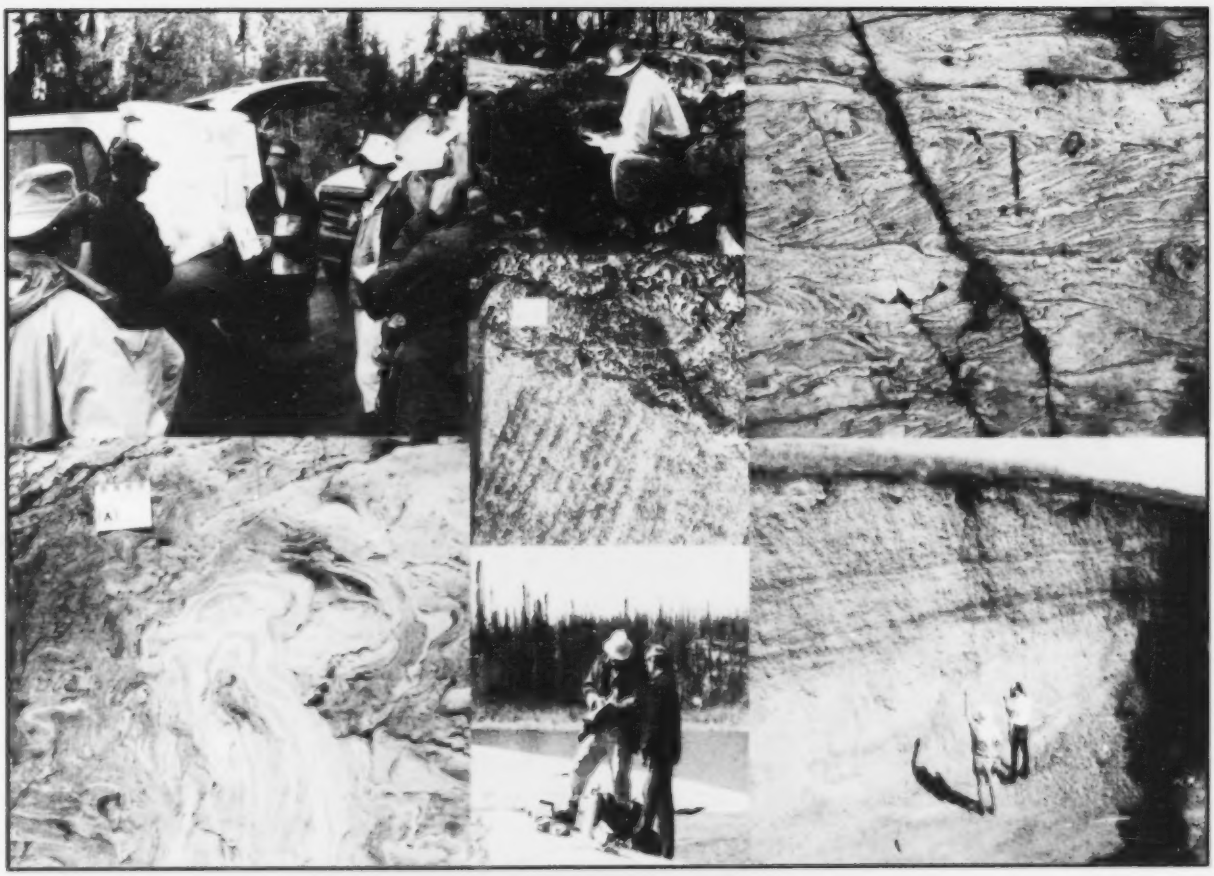
Saskatchewan
Geological Survey

November 29 to December 1, 2004

Open House 2004

Abstract Volume

Saskatchewan Geological Survey



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Printed under the authority of the
Minister of Industry and Resources

Although the Department of Industry and Resources has exercised all reasonable care in the compilation, interpretation, and production of this report, it is not possible to ensure total accuracy, and all persons who rely on the information contained herein do so at their own risk. The Department of Industry and Resources and the Government of Saskatchewan do not accept liability for any errors, omissions or inaccuracies that may be included in, or derived from, this report.

Cover:
Centre: The 2.56 Ga Swan River Complex in the Peter Lake Domain has good examples of cumulate igneous layering that likely formed in a well stratified magma-chamber. Rhythmic layers of gabbro and leucogabbro are disrupted by pegmatitic gabbro, indicating the presence of volatile-rich intercumulus liquid, from which primary hydrous mineral phases likely crystallized. Such pegmatitic textures are common to reef-type PGE occurrences (see Maxeiner *et al.*, this volume).
Clockwise from upper left:
Kimberley Bailey, M.Sc. candidate, Laurentian University, explaining the stratigraphy of the Myo Rhyolite, Flin Flon (see Bailey and Gibson, this volume).
Mike Gunning examining a clinopyroxene-allanite-bearing dyke in trench 11 at the JAK zone, Hoidas Lake (see Gunning and Card, this volume).
Pink migmatite from the Rottenstone Domain southeast of Kenyon Lake (see MacLachlan *et al.*, this volume).
Lynn Kelley and summer student Amanda Perrot at an exposure of Miocene Wood Mountain Formation fluvial gravel in a pit south of Glentworth, Saskatchewan (see Kelley and Yeo, this volume).
Ken Ford, Geological Survey of Canada, and Janet Campbell recording radiometric data, Peter Lake Domain (see Campbell, this volume).
Type 2 fold interference pattern in pre-1.9 Ga mylonitized paragneisses from 1 km east of Camsell Portage on the northern shore of Ellis Bay, Lake Athabasca (see Hunter *et al.*, this volume).
Photos by staff of Saskatchewan Industry and Resources.

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2007-02366/

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Technical Session 1: Athabasca Uranium, CO_2, New Geoscience, Land-use Planning, and Mineral Statistics

EXTECH IV – Athabasca Uranium Multi-disciplinary Study: Insights

C.W. Jefferson [1], G. Delaney [2], D.J. Thomas [3], C. Cutts [4], R.A. Olson [5], S. Ahuja [6], I. Annesley [7], S. Bernier [8], D. Brisbin [3], J.E. Campbell [2], C. Card [2], O. Catuneanu [9], B. Collier [8], J.A. Craven [1], S.S. Gandhi [1], I. Gyorfi [10], Z. Hajnal [10], S. Harvey [2], R. Koch [4], B. Kupsch [9], D.G.F. Long [8], C.J. Mwenifumbo [1], D. Pana [5], P. Portella [4], R. Post [3], B. Powell [3], P. Ramaekers [11], R.B.K. Shives [1], V.J. Sopuck [3], V. Stasiuk [1], E. Takacs [10], M.D. Thomas [1], G. Tourigny [12], K. Wheatley [4], D.J. White [1], N. Wilson [1], G. Wood [3], and G.M. Yeo [2]

Abstract

EXTECH IV was designed to: (i) enhance the geoscience framework and deep-exploration technology for unconformity-associated uranium deposits in the Athabasca Basin; (ii) stimulate further mineral exploration and employment in remote northern areas; (iii) document, upgrade and archive existing data for posterity; and (iv) train young scientists and increase government and university capacity in this topic. These objectives were met because of the strong support and participation of all partners. Here we provide some thematic insights, based on integrated multiple lines of research, to assist in uranium exploration at this time of increased demand for clean energy.

The relationship between the Athabasca Group unconformity, faults, graphitic basement conductors, and uraninite accumulation has been studied since the discovery of the Rabbit Lake deposit in 1968. Analysis and targeting of these features have been an increasing part of the exploration framework ever since. Through EXTECH IV, detailed mapping of the Sue and Deilmann open pits, and integrated geological-geophysical transects at McArthur River have improved our understanding of spatial relationships between basement geology, sedimentation, diagenesis, alteration, and ore deposits. In particular, detailed basement mapping during mining at the Sue C deposit demonstrated a direct spatial and temporal association between transpressional reactivation of ductile Hudsonian basement fault zones and high-grade uranium deposits. Massive uraninite was emplaced in dilatant jogs of the complex graphitic Sue deformation zone whose geometries predict the Sue C deposit's overall geometry. A number of these fault zones across the Athabasca Basin are interpreted to have served as hinge lines bounding regional sub-basins. It is inferred that most of these faults were minor growth faults and active at different times in different places throughout the pre-, syn-, and post-depositional history of the Athabasca Group.

Variation in the basement paleotopography is an important corollary to the growth of fault structures, including paleo-valleys, with associated local red mudstone and conglomerate units, paleocurrent anomalies, and basement quartzite ridges. Furthermore, syn- and post-sedimentation uplifts and depressions have been spatially and temporally related to repeated brittle-fault reactivation. These reactivations are linked to diagenetic and hydrothermal events including mineralogical alteration haloes, which include clays, dravite, quartz cement or dissolution, and uraninite deposition. Geophysical methods including high-resolution seismic, audiomagnetotelluric and gravity transects, multiparameter borehole geophysics, ground and airborne gamma-ray surveys, and airborne-magnetic surveys, are capable of detecting and mapping different facets of these exploration targets at regional to detailed scales.

Graphitic basement units associated with the fault zones are an essential component of uranium deposit systems in the Athabasca Basin. The Wollaston and eastern Mudjatik domains, which underlie the eastern Athabasca Basin, contain graphitic units of the basal Wollaston Supergroup. Similar, but not necessarily equivalent, graphitic units are associated with western Athabasca deposits of the Carswell Structure and at Shea Creek and Maybelle River. These graphitic metasedimentary rocks are zones of weakness in which ductile shear zones propagated and were the sites of repeated reactivation. The graphitic units have long been known as strong electromagnetic conductors and

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excellent exploration targets. Further, they are included as a key genetic component in a variety of geochemical and electrochemical models involving hydrothermal processes, for unconformity-associated uranium deposits. Although laboratory studies have suggested that these graphitic units could have been a source of some hydrocarbon reductants, EXTECH IV organic and paragenetic studies indicate that quantitatively significant pyrobitumens postdated most uraninite and were derived from Douglas Formation oil shales and/or Cretaceous heavy oils.

Revised Stratigraphy of the Athabasca Group

Gary Yeo [1], Paul Ramaekers [2], and Charlie Jefferson [3]

Abstract

An improved understanding of Athabasca Basin stratigraphy is important because some of the ore is hosted in the sandstone, diagenetic permeability (i.e., stratigraphic anisotropy) has controlled the movement of mineralizing fluids, and stratigraphic offsets are a guide to the reactivation history of long-lived faults commonly associated with uranium mineralization.

The stratigraphic nomenclature of any basin is not static, but evolves over time. The "Athabasca sandstone" was first described by McConnell in 1893, but later workers expanded it to include older strata now distinguished as the Martin and Thluicho Lake groups. In 1961, Fahrig recognized the Athabasca Formation as a little-deformed, upward-fining succession of sandstone with minor shale, overlain by carbonates of the Carswell Formation. In the course of fieldwork in the late 1970s, Ramaekers developed the stratigraphic framework of the Athabasca Group which has served up to the present.

Limitations in this stratigraphic scheme have become apparent in the last decade. Attempts to correlate strata across the basin have been frustrated by lateral variation not clearly accommodated in the stratigraphic nomenclature. Correlation has been further complicated by recognition of stratigraphic boundaries in southwestern Athabasca Basin which are inconsistent with those recognized to the east.

Although the revised stratigraphy which has arisen from the EXTECH IV project appears to be complex, there are no radical changes at the formation level. All of the existing formation names are preserved, except for the Tuma Lake Formation, now recognized as up-faulted Locker Lake Formation. The only new formation names introduced are for previously un-named local units at the base of the Manitou Falls Formation: the Reilly, Read, and Smart formations which respectively are at the Reilly Lake outlier east of Reindeer Lake, eastern Athabasca Basin, and south of the Carswell Structure. The only formation boundaries that are re-defined are the base of the Manitou Falls locally (as above), and the Lazenby Lake–Wolverine Point boundary, now moved up to include the former WPa member within the Lazenby Lake Formation. A number of new members and submembers are distinguished, in recognition of the lobate geometry of lithofacies units within each of the basin's deposystems. For convenience, acronyms for most new member names within the Manitou Falls Formation are consistent with the old ones.

A key objective of the EXTECH IV Stratigraphy Sub-project was to improve basin-scale correlation. The layer-cake approach to the basin's stratigraphy (based partly on interpretation of most formations as marine) did not work well. The revised stratigraphy recognizes that most of the strata were deposited in lobate fluvial deposystems. The currently used scheme was developed mainly on the basis of outcrop observations, before intensive exploration of Athabasca Basin really began, whereas the revised stratigraphy is largely based on detailed logging of a large number of drill cores. As most exploration geologists are concerned with distinguishing units in core rather than in outcrop, this is an important improvement.

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Recent Surface and Underground Exploration Activities in the Eagle Point Deposit Area

Cory Belyk [1] and Roger Lemaitre [1]

Abstract

Exploration in the Rabbit Lake area, which is located in the extreme eastern edge of the Athabasca Basin, has been ongoing since the mid 1960s. The Rabbit Lake deposit, discovered by Gulf Minerals in 1968, was the first deposit found in what has since become the most prolific uranium-producing district in the world. Uranium production commenced in the fall of 1975 and in the nearly 30 years that have followed, some 150 million pounds of uranium has been produced from five separate deposits on the property. Recent production at Rabbit Lake has come from the Eagle Point underground operation.

Following a period of inactivity, surface exploration resumed at Rabbit Lake in 2001 with drill core mapping, data compilation, and ground geophysical programs. Initial emphasis was to assess the exploration potential, within 1000 m of the current Eagle Point underground infrastructure, for satellite discoveries to support the mining operation prior to its scheduled decommissioning in 2005. The first surface drilling was undertaken in the winter of 2002. Modest results were obtained from an area located 425 m north of the Eagle Point underground workings. Three zones of uranium mineralization were intersected in two drill holes; the best intersection yielded 1.2% eU_3O_8/ 1.75 m.

Thirty-three surface holes were drilled in the area of the new intersections during the follow-up program in winter of 2003. These holes outlined a new mineralized body known as the 02 North Extension Zone.

Mining operations recommenced at Eagle Point in early 2002 after an approximate four year shut-down period. At restart, the known Life-of-Mine (LOM) reserves were approximately 18 million pounds U_3O_8. Currently, after almost two years of production, the LOM reserve is approximately 16 million pounds U_3O_8 with mining operations planned to extend into 2007. Mine-scale exploration has been ongoing since 2002 and has located additional resources and reserves in the Sump Zone, 163 Zone, and 02 Deep areas of the Eagle Point Mine. Underground delineation drilling of the 02 North Extension Zone has confirmed the resource and established a new mining front located approximately 450 m north of the original Eagle Point ore bodies. The first ore production from this zone is expected in late 2005, once sufficient infrastructure development is completed. Current exploration activity is focussed along the 163 Zone structure east of the present mine workings. Underground drilling along this structure continues to yield positive results that will likely impact future mining at Eagle Point.

Today, a coordinated surface and underground exploration program is continuing to identify and test targets in the immediate Eagle Point area. The development of a new deposit and structural model is enabling Cameco to generate new ideas and identify prospective geological targets that remain untested, as shown by the case histories of the 02 North Extension and 163 Zone discoveries. Cameco is confident that drill testing of these new targets will ensure that the Eagle Point Mine has a very bright future.

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Moore Lake Uranium Project

D. Billard [1], R. Kusmirski [1], and R. Hochstein [2]

Abstract

Uranium exploration in the Moore Lakes area has been carried out periodically throughout the past 30 years. In 1999, JNR Resources staked an initial three claims over the Moore Lakes area, where historic drilling had identified strongly graphitic metapelite assemblages, anomalous geochemistry, and weak uranium mineralization. In the spring of 2000, JNR Resources and Kennecott Canada Exploration carried out 50 km of TEM followed by five diamond drill holes. In the third hole of the program, 0.442 e% U_3O_8 / 9.20 m was intersected, in what is now known as the Maverick zone. Follow-up drilling that summer (nine holes) confirmed the presence of a significant structural zone accompanied by an intense hydrothermal system, along with highly enriched trace element geochemistry.

In 2001, 1500 line km of Airborne GEOTEM was flown, followed up by extensive ground TEM, gravity and magnetics over four new areas which were drill tested: MLE, Raratonga, Venice, and Puka Puka. Beneath the main Puka Puka grid, anomalous geochemical values were intersected in strongly disrupted sandstone and graphitic metapelites; anomalous radioactivity and geochemistry were intersected in felsic intrusives at the MLE and Venice grids. In 2002, additional TEM and five drill holes were completed on the Maverick area. That program yielded the best hole to that date in the Maverick 02ML-25 which returned 0.62% U_3O_8 / 9.1 m below the unconformity, including an interval of 12% U_3O_8 / 0.4 m. This was the project's first indication of high grade mineralization.

In October of 2002, Kennecott informed JNR of it's intent to discontinue exploration on the property. A year later, JNR signed an agreement with International Uranium Corp. (IUC) whereby they could earn up to a 75% interest in the property by making aggregate expenditures and investments of $4.4 million.

Since that time, the joint venture has carried out two aggressive drilling programs totalling nearly 20 000 m in 52 holes. The drilling has significantly expanded the known extent of the mineralizing system to the northeast of ML-25 by a minimum of 1.2 km. The bulk of the drilling has focused on a strike length of over 200 m in the vicinity of ML-03 and ML-25. The best results, which are from that region, are from drill holes ML-48 (4.02% U_3O_8 /4.7 m), ML-55 (5.14% U_3O_8 / 6.2 m), and ML-61, where an intercept of 4.03% eU_3O_8 / 10.0 m was intersected, including 1.5 m of 20% eU_3O_8. The entire 1.8 km of the mineralizing system tested to date is highly illitic, with significant uranium and boron enrichment in the sandstone, and intense clay alteration extending for tens of metres into the basement rocks. A minimum of 1.5 km of the currently identified Maverick conductor has yet to be drill tested at this time.

The joint venture is currently planning a winter program that will include 3D Seismic, gravity, TEM, and ground magnetics, and a minimum of 15 000 m of drilling in the Maverick zone, its northeast and southwest extension, and on a number of regional targets including the Puka Puka, Venice, and MLE.

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From Greenhouse Gas to Shallow Gas: There's More Than Just Hot Air in Saskatchewan's Phanerozoic Succession

S.G. Whittaker [1], C.F. Gilboy [1], A. Costa [1], F.M. Haidl [1], L.K. Kreis [1], P.K. Pedersen [1], M. Yurkowski [1], E.H. Nickel [1], and A. Nimegeers [1]

Abstract

The Phanerozoic strata of Saskatchewan contain abundant oil, natural gas and potash, each of which is a major contributor to the provincial revenue and GDP, and together mainly comprise the province's largest goods-producing industry. In fact, Saskatchewan produces about 20% of Canada's crude oil and is the second largest oil-producing province. As many of Saskatchewan's existing oil fields are entering a mature phase of development, enhanced oil recovery (EOR) methods are becoming increasingly important in sustaining production of this resource. The Petroleum Geology Branch has been involved in a large-scale project studying the injection of CO_2 into the Weyburn Field operated by EnCana Corp. in southeastern Saskatchewan. This miscible-flood EOR-technique is projected to increase the life of the Weyburn Field by 25 years and yield an additional 120 million barrels of oil. An addition, primary focus of the study was to investigate the potential of storing the injected CO_2 in the reservoir for the long-term (ca. 1,000s years) as a method of mitigating greenhouse gas emissions to the atmosphere. The first phase of this study was completed July 2004.

Although Saskatchewan has a long history of hydrocarbon exploration, much of the province is under-explored and specific stratigraphic intervals under-examined. For example, it is only during the past several years that the remarkable potential for shallow gas has been realized. The Shackleton Field, discovered in 1999 in shallow Cretaceous strata and essentially on production only since 2002, now accounts for about 13% of all Saskatchewan gas production. Regional and detailed geological mapping in western Saskatchewan has helped to reveal some of the mechanisms behind these shallow unconventional gas plays, and indicate that it is very unlikely that a Shackelton-like play is a one-time occurrence. Coal-bed methane potential in the province, a rapidly emerging opportunity for gas exploitation, is also being investigated as part of regional and focused studies. Because updated regional geological maps assist both government and industry geologists in assessing resource potential and devising exploration strategies, a major program is underway to map the northeastern portion of the Williston Basin by SIR, Manitoba Energy and Mines, and the Geological Survey of Canada through a Targeted Geoscience Initiative (TGI). The Williston Basin Architecture and Hydrocarbon Potential TGI project will result in a more "seamless" stratigraphy across the basin and provide an updated hydrocarbon assessment of the region. In addition, a recent initiative involving a number of U.S. states to study the potential of geological sequestration of CO_2 in the mid-continent may result in a further extension of regional mapping to encompass the entire Williston Basin. An updated stratigraphic framework for the entire province should be complete by the end of 2006.

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Cooperative Geological Mapping Strategies Across Canada: Public Geoscience, Exploration, and Development

Simon Hanmer [1]

Abstract

Improving the quality of life of Canadians is a priority shared by governments across this country. Secure and affordable energy supplies, sustainable resource-based communities, self-reliant Aboriginal peoples, and sound environmental stewardship figure prominently among government policy goals in most jurisdictions. Mineral and energy resources underpin prosperity in much of Canada, and constitute the only significant opportunities for economic growth in many rural, remote, and northern parts of the country. Canada possesses significant untapped mineral and energy potential. The recent discoveries of diamonds in the Canadian Shield and of gas hydrates in the North and offshore are but two examples that demonstrate that exploration has barely "scraped the surface".

Mineral exploration expenditures have increased in Canada since 2000. However, exploration has focused on diamonds and gold, and has not achieved the levels required to sustain base metal reserves. This decline in reserves is occurring in the face of increasing global demand for metals and, if the trend continues, will mean both lost opportunities for Canada and economic disruption for many resource-based communities.

Energy supply also represents a challenge. According to various National Energy Board projections, conventional oil and gas production has either peaked already or will do so in the near future. Canada will need to rely increasingly on unconventional resources such as oil sands and coal-bed methane. At the same time, it will be important to optimize recovery of conventional resources.

Canada's potential for new mineral and energy res ces is arguably as great as that of any country in the world. In order to translate that potential into long-term employment and sustained prosperity, however, new resources must be discovered. In today's global economy, a modern, accessible public geoscience knowledge base is recognized as a key competitive advantage in profiling a jurisdiction's geological potential and attracting both domestic and foreign investment in resource exploration and development. Public geoscience is also essential for informed resource development policy and land-use decisions.

Studies have consistently shown that investment in public geoscience stimulates private sector investment in exploration and development. Every $1 million of government investment to enhance the geoscience knowledge base is expected to stimulate $5 million of private sector exploration expenditures, which, in turn, will result in discovery of new resources with an in situ value of $125 million.

Canadian industry and non-government organizations have repeatedly alerted governments to the fact that Canada is faced with significant public geoscience knowledge and capacity gaps, compounded by inadequate human and financial resources to fill them. Recognizing the need for action, Canada's Mines Ministers unanimously endorsed the Cooperative Geological Mapping Strategies Across Canada (CGMS) proposal to renew the public geoscience knowledge base at their annual meeting in September 2000. In 2003, the Ministers directed the National Geological Surveys Committee (NGSC) to develop the implementation plan for CGMS.

The CGMS implementation plan developed by the NGSC, defines a suite of strategic initiatives and project activities that target four principal outcomes:

- *a secure energy supply for Canada,*
- *prosperous resource-based communities,*
- *new economic development opportunities, underpinned by*
- *environmentally responsible stewardship of geological resources.*

The total incremental investment required to achieve these outcomes is approximately $500 million over 10 years. As agreed by Ministers in 2000, funding allocations in each province and territory would be determined through bilateral negotiations once the level of federal investment in CGMS is determined.

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[1] Natural Resources Canada, Geological Survey of Canada, 601 Booth Street, Ottawa, ON K1A 0E8.

A key element in the CGMS implementation plan is a regional approach to public geoscience. This approach is important because prospective geology that either hosts or influences the distribution of mineral and energy resources crosses jurisdictional boundaries. A regional approach to CGMS also presents the opportunity for complementary capacity and knowledge sharing among the geological surveys, universities, and industry, through the creation of innovative partnerships. Geoscience needs and gap analyses, recently undertaken by the provinces and territories and the Geological Survey of Canada, will form the basis for jurisdictional commitments to the CGMS initiative. An innovative approach to knowledge delivery will ensure more effective discovery and utilization of public geoscience by end-users.

An ancillary benefit of CGMS will be a general strengthening of the structure and coordination of public geoscience across Canada. This will lead to a substantial contribution to the training of young Canadians in order to meet the growing need for highly qualified personnel throughout the geological resource sector. Where appropriate, this training will also embrace the needs and capacity of Aboriginal people to participate fully in the geological resource-based economy and associated industries.

Canada's geological surveys have an excellent record of productive collaboration and CGMS will, to the extent possible, make use of existing governance mechanisms. The Cooperation Committee (or equivalent) in each province and territory, comprising senior managers from federal and provincial or territorial departments carrying out geoscience programs in that province or territory, will be responsible for establishing priorities for collaborative projects and overseeing their implementation. These Cooperation Committees will seek advice on project priorities and feedback on project delivery from industry and other stakeholders, either through existing Technical Liaison Committees or through other representative groups appropriate for the jurisdiction.

The NGSC will coordinate the implementation of CGMS across Canada. In particular, it will promote innovative, multilateral approaches to broadly regional geoscience questions. A CGMS Advisory Committee, chaired by industry leaders, will be established with membership drawn from the technical liaison committees in each jurisdiction, as well as from major industry associations. The CGMS Advisory Committee will review the overall implementation of the strategies from the standpoint of alignment with CGMS goals and delivery of results, and report on progress annually to Mines and Energy Ministers, thereby ensuring transparency, and accountability to stakeholders and Canadians.

Although the NGSC has already benefited from considerable input from industry and other stakeholders concerning the gaps in the geoscience knowledge base and the kinds of activities that would be required to fill those gaps, it has not proceeded to the point of identifying and prioritizing the specific projects that would be pursued under CGMS. In the Fall of 2004, the NGSC will engage industry, academic, and community stakeholders with the goal of defining the CGMS project portfolio, and the developing the technical and financial partnerships required to carry them out. In other words, a key next step is to develop the operational plan or 'technical blueprint' for CGMS.

A Progress Report on the Regional Land-use Planning Process and the Representative Areas Network Program in Saskatchewan

Murray C. Rogers [1]

Abstract

The Government of Saskatchewan is currently involved in numerous regional integrated land-use planning exercises. The planning processes usually only directly involve Crown surface lands. Saskatchewan Environment (SE) initiates and leads the land-use plans under their management, mainly in the north. Saskatchewan Agriculture, Food and Rural Revitalization (SAFRR) leads the plans under their management, mainly in the south. The public advisory planning committees that develop the plans consist of representatives for community and interest groups. The mining and/or oil and gas industries are members of the committees on most of the plans. Representatives of the government departments act in advisory and resource capacities. Saskatchewan Industry and Resources (SIR) participates in the development of all of the plans.

Important considerations for industry are potential restrictions on surface access and activities that may result from these processes. These include the review of Representative Areas Network (RAN) site proposals; regional zoning on land use; buffers around water bodies, historical, cultural, archeological, and ecological sites; and the establishment of wildlife management areas. Other relevant issues that are commonly discussed include road and trail development and closure, public consultation, compensation, and environmental monitoring of activities.

Eleven land-use plans have been completed and are being implemented. These are the Amisk-Atik (2004), RM Stove Creek (2003), La Ronge (2003), Whitehood (2002), RM Torch River (2002), Prince Albert Model Forest (2000), Pasquia-Porcupine (1998), Fur Lakes (1998), Fowler and Murphy lakes (1997), Manitou Sand Hills (1996), and Great Sand Hills (1991).

There are currently nine land-use plans that are being developed in the province. SE led planning processes include Fort à la Corne Provincial Forest, Buffalo Pound Lake, North-Central, Pinehouse-Dipper, Athabasca Road Corridor, and Nisbet Provincial Forest. SAFRR led plans include Bjorkdale and Grand Cheviot.

The Government of Saskatchewan, with SE as the lead department, initiated the Representative Areas Network (RAN) program in 1996. The RAN is composed of lands and waters selected and designated to represent the natural ecological and biological diversity of the province and managed to retain that diversity. RAN sites act both as reservoirs of biological diversity and benchmarks for comparison with the more heavily used landscape. There are 11 ecoregions in the province to represent. The RAN includes the existing parks and other previously designated lands. Other government departments, including SIR, are actively involved in the RAN selection process, as well as the general public and industry.

A specific process exists for the review of the RAN site proposals by SIR and industry. SIR initially carries out technical reviews of the mineral (and oil and gas) potential of the proposed sites using qualitative mineral resource assessments that are based on compiled geoscience, mineral deposit, and exploration information. The intent is to locate the RAN sites in areas of low assessed mineral potential. Proposals that may be acceptable are forwarded for review and comment to a range of industry organizations, companies, and individuals, including any disposition holders in the region. Public review of RAN site proposals is often done through the land-use plans.

Since 1997, 37 sites totaling about 665 000 ha have been formally designated under the RAN program. The only formal designations in 2004 were in the Pasquia-Porcupine area. Boundary adjustments were made to 12 pre-existing sites, one new site was added, and five sites were removed.

A number of proposed sites, some very large, are currently at various stages of review and discussion by SE, SIR, and industry. These include Tazin Lake (NTS 74N), Chappuis-Fontaine lakes (NTS 74O), Misaw Lake (NTS 64M), Pink Lake (NTS 74A), Geikie River (NTS 74A, 74H), Cree Lake (NTS 74B, 74G), Firebag Lake (NTS 74C to 74F), Fort à la Corne (NTS 73H), Nisbet River (NTS 73G), and Nisbet Upland (NTS 73B). The Cree Lake, Nisbet River, and Nisbet Upland site proposals have been reviewed and approved by SIR and industry but have not been formally designated. The public will review most of these proposals through land-use planning processes. Interim 10 year surface designations, that allow mineral exploration and development, have been established by SE on the proposed Tazin Lake, Chappuis-Fontaine lakes, and Misaw Lake sites until decisions are made on any formal designations.

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Prospects to Production: Contributions of the Saskatchewan Mineral Industry

P.L. Schwann [1]

Abstract

The mineral industry is projected to invest over $50 million in grassroots exploration for metallic minerals in Saskatchewan during 2004, an increase of $19 million over the $31 million invested in 2003. Exploration for diamonds is the primary focus of investment and constitutes almost half of the proposed exploration investment. The two main diamond exploration projects, the Star Kimberlite and Fort à la Corne Joint Venture, are at an advanced and more costly stage of exploration. Exploration for uranium in the Athabasca Basin remains a staple of exploration investment with over three dozen active exploration programs expending over $20 million in 2004. Fueled by a steady increase in the price of uranium from US$10.20/lb in January 2003 to US$20.25/lb in October 2004, uranium exploration activity is expected to remain very strong.

The current strength of the exploration sector is also reflected in the amount of Crown mineral lands that have been acquired in 2004. Prime areas of interest are related to uranium exploration in the Athabasca Basin and to diamond exploration in the Fort à la Corne area. As of October 31, 2004, 4008 metallic mineral dispositions covering 2.8 million ha of Crown mineral lands were in good standing. Activity in the industrial minerals sector remains stable. There are 942 active industrial mineral dispositions for potash, coal, sodium sulphate, and quarriable substances that cover 345 642 ha. In total, there are currently 4950 active metallic and industrial mineral dispositions covering a total of 3.15 million ha of Crown mineral lands.

The $1.2 million annual Corporation Exploration Incentive Program (CEIP) and Prospector Incentive Program (PIP) are now in their third year. In the 2003-2004 year, the CEIP was oversubscribed, with nineteen companies receiving funding. Ten prospectors also received funding through the PIP. In 2004-05, there was again strong uptake for the CEIP, with 31 companies applying for the program. Although the CEIP will again be oversubscribed in 2004-05, the PIP continues to be undersubscribed. The Saskatchewan Mineral Exploration Tax Credit is anticipated to be strongly subscribed to in 2004 as close to $30 million has been raised by eligible junior mineral exploration companies in 2004.

In 2004, uranium mining/milling activities continued at the McArthur River/Key Lake and Eagle Point/Rabbit Lake sites, while milling of stockpiled ore from SUE C continued at the McClean Lake site. Primary gold production continued from the Seabee Mine operated by Claude Resources Ltd., as well as copper, zinc, and secondary gold and silver production from the Callinan and Konuto Mines. Recovery of gold and copper from the tailings of the historical Anglo-Rouyn Mine on the north shore of Lac La Ronge also began in 2004.

Saskatchewan remained Canada's third largest, non-fuel mineral producing province in 2003. In 2004, twenty-nine mine operations across Saskatchewan produced a diversity of minerals including potash, uranium, coal, gold, copper, zinc, and silica sand for a combined value of sales of $2.4 billion. With increased production and increased prices for potash and uranium, 2004 should be an even more prosperous year for the mineral resource industry in Saskatchewan.

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Technical Session 2: Trans-Hudson Orogen and its Metallogeny with a Focus on Gold

Tectonic Assembly and Metallogeny of the Trans-Hudson Orogen: An Overview

David Corrigan [1]

Abstract

The Trans-Hudson orogeny (THO) represents one of the most significant craton-building events in the evolution of North America. Significantly, continental plates that had formed over the time-span of the Archean had finally attained the order of spatial dimensions and physical properties akin to modern continental plates, thus providing similar boundary conditions for tectonic, depositional, and metallogenic processes. This presentation focuses on the closure of the Manikewan Ocean and ensuing Churchill-Sask-Superior collision, based on constraints from the western THO and Baffin/Cape Smith segments.

During the opening and closure of the Manikewan Ocean, the following sequence of events occurred:

1) *Deposition of passive margin sequences, beginning at ca. 2.16 Ga.*
2) *Ocean closure beginning at ca. 1.92 Ga in the western THO, leading to the formation of the La Ronge/Lynn Lake and Flin Flon/Glennie arcs.*
3) *Beginning at about 1.88 Ga, accretion of the La Ronge/Lynn Lake arcs to the Hearne margin and related deposition of an extensive molasse/foredeep sequence. This event was contemporaneous with intraoceanic accretion leading to the formation of the Flin Flon/Glennie accretionary complex.*
4) *Continental arc magmatism along the southeast margin of the Churchill plate between 1.86 Ga and 1.85 Ga.*
5) *Cessation of continental arc magmatism at about 1.850 Ga, perhaps related to collision of the Flin Flon/Glennie complex (western THO) and Narsajuaq arc (Baffin segment), with the Churchill plate.*
6) *Opening of the Kisseynew back-arc basin during the interval 1.85 to 1.84 Ga, with the Flin Flon complex now forming part of the active arc and Granville Lake Structural Zone forming part of the remnant arc.*
7) *Collision between the Sask Craton and Churchill Plate, beginning at ca. 1.84 Ga, leading to the inversion of the Kisseynew basin and deposition of molasse deposits.*
8) *Terminal collision involving the Superior Province, beginning at ca. 1.83 Ga and ongoing until approximately 1.77 Ga.*

The wide range of depositional and tectonic environments, metamorphic facies, and degree of deformation or reactivation are conductive for the generation and structural concentration of many types of base and precious metal deposits. This presentation will provide a brief overview of the 'classic' base and precious metal deposits of the THO, but we will also discuss other known and less well known deposit types that may occur in different parts of the orogen.

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New Results and Ideas from the Rottenstone Domain Project

Kate MacLachlan [1], Nicole Rayner [2], Greg Dunning [3], and Chad Leugner [4]

Abstract

In 2004, geological mapping was continued near Rottenstone Lake and initiated at Davin Lake. At Rottenstone Lake, pink and white migmatite successions were recognized. The pink migmatite succession is characterized by pink leucosome and grey psammitic paleosome, with magnetite in both the granite and sedimentary components. In contrast, the volumetrically predominant white migmatite succession is graphite bearing. The white migmatite was derived from a sedimentary package with abundant pelite, as well as various amounts of psammite and psammopelite, calc-silicate, quartzite, amphibolite, and melanocratic biotite ± hornblende-quartzofeldspathic gneiss. Similar pink and white migmatites occur in the Davin Lake area.

SHRIMP detrital zircon studies of two samples, quartzite and psammite from east of Hickson Lake in the Crew Lake Belt, indicate that these rocks are composed of both Archean and Paleoproterozoic detritus. Zircon ages from the quartzite suggest that it is derived entirely from a continental source. Prominent peaks in the cumulative probability plot at ca. 2.44 and 2.51 Ga are most compatible with continental crust similar in age to the Sask Craton, although some contribution from Hearne age crust cannot be ruled out. The psammite has a significant proportion of detrital grains in the same age range as the quartzite, but also has a prominent and well-defined age mode at 1.89 Ga, likely derived from volcanic detritus from the La Ronge arc.

U-Pb ages for metamorphic and igneous rocks in the central Rottenstone domain indicate that transposition of compositional layering and the pre-migmatization metamorphic fabric into the composite tectonic foliation (S_{main}) occurred after ca. 1833 +5/-4 Ma, the age of a foliated biotite monzogranite sheet that pre-dated S_{main}. This granite sheet is in the core of an early (F_2) tight to isoclinal fold of S_{main} and thus, provides a maximum age constraint for F_2 folding. F_2 folding was probably more or less synchronous with the main migmatizing event. A biotite granodiorite with pelitic restite inclusions has an age of about 1825 Ma and monazite from the adjacent pelitic migmatite is 1822 ±2 Ma. The final phase of upright to inclined, open asymmetric folding occurred after 1814 ±4 Ma, the age of late K-feldspar porphyritic monzogranite.

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Geological Relationships Along a Transect of the Southwestern Rottenstone Domain, Trans-Hudson Orogen

Kathryn M. Bethune [1]

Abstract

The Rottenstone Domain is a northeast-elongate belt of high-grade gneissic and migmatitic rocks in the northwest margin of the Reindeer Zone of the Trans-Hudson Orogen. The belt is dominated by a "tonalite-migmatite complex" consisting of variably migmatized supracrustal rocks invaded by a variety of granitoid rocks of suspected Paleoproterozoic age. Along the northwestern margin of the domain, these rocks were intruded by the ca. 1.86 Ga Wathaman Batholith. The origin of Rottenstone Domain is contentious. The domain has been interpreted as either: 1) the deeper level (root) of the La Ronge arc; or 2) a continental magmatic arc built on an extended Hearne margin. The recent discovery of Archean rock in an antiformal culmination in the south-central part of the domain raises new questions concerning its tectonic context, in particular how Paleoproterozoic rocks of the "tonalite-migmatite complex" interacted with Archean crust of the Hearne and Sask cratons. This talk presents preliminary results from a regional northwest-southeast transect of the southwest part of the domain along the Churchill River whose objectives were to determine the extent and affiliation of the Archean crust in this culmination (Hearne vs. Sask craton?) and its relationship to surrounding gneissic rocks.

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Saskatchewan Gold Deposits

S. Modeland [1]

Abstract

Over the past few decades, northern Saskatchewan has been the focus of major gold exploration. Since 1932, more than five million ounces of gold has been produced. Although most of this production has been a by-product from base-metal deposits, approximately 1.3 million ounces have been recovered by primary gold producers. With the recent rise in gold prices, attention is once again focused on northern Saskatchewan gold potential. There are over 500 gold occurrences documented within the province and some of these showings have come into production and have subsequently been mined out during the 1980s and early 1990s.

The majority of the gold occurrences are classified as shear-hosted quartz vein (Mother Lode-type) and occur mainly within the La Ronge and Glennie domains. These deposits are generally associated with plutonic rocks and subsidiary shear zones related to major regional-scale structures.

Gold-rich massive sulphides (VMS-type) account for ~65% of the total gold production in Saskatchewan. These occurrences occur predominately in the Flin Flon Domain and have anomalous gold concentrations relative to typical VMS-deposits. The ore bodies are commonly zoned massive-sulphide lenses with gold and silver contents increasing with depth.

Despite the dominance of sheared-hosted and VMS-associated gold deposits, there are other deposit-types that contain significant gold concentrations such as: iron formation-hosted vein and disseminated types, unconformity-associated types, stratiform sediment-hosted types, paleoplacer, and fluvial deposits.

A classification scheme categorizing Saskatchewan gold occurrences is used to identify important parameters in order to provide a framework for gold-exploration strategies. Using available databases such as: geological setting, structure, aeromagnetic, and geochemistry, a deposit-specific gold-potential map of the La Ronge Domain is being developed. Future work will continue with data compilation for all of the lithostructural domains and the Phanerozoic Basin in order to generate a gold-potential map of Saskatchewan.

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Structural Controls and Temperature-Pressure Conditions of Gold-bearing Quartz Vein Systems at the Seabee Mine, Northern Saskatchewan

Ghislain Tourigny [1], Guoxiang Chi [2], Chad Yuhasz [3], Rob Olson [3], Jennifer Berger [3], and Jennifer Soloman [3]

Abstract

The Seabee mine is a Paleoproterozoic vein-type gold deposit hosted by metagabbroic rocks of the Laonil Lake Intrusive Complex, northern Saskatchewan. Results from a detailed structural analysis indicate that two different styles of gold mineralization coexist within the deposit. The principal auriferous orebody occurs in Lens 2, which is composed of anastomosing, east-northeast–trending, ductile-brittle shear zones, whose internal geometry and kinematics indicate a bulk dextral transpression along the mineralized megashears. Deformed auriferous veins occur as Riedel 'R' and 'P' veins oriented 5° to 15° from the shear foliation, fault-fill veins subparallel to the foliation, and minor extension veins oriented at a high angle to the shear zone boundary. The second structural style of gold mineralization consists of conjugate quartz veins within steeply east-dipping tabular bodies developed at the margin of the east-northeast–trending Lens 5 shear zone. The conjugate vein system developed to accommodate the component of compression oblique to the general east-northeast shear direction. Vein mineralogy is similar in both east-northeast–striking shear zones and within the conjugate network, and is dominated by quartz, tourmaline, and sulphides with minor carbonate, feldspar, and white mica. Pyrite and pyrrhotite are the major sulphide phases; chalcopyrite and sphalerite are minor. Silver-bearing gold grains shows a close spatial association with tellurides that include melonite ($NiTe_2$) and tellurobismuthite (Bi_2Te_3) with minute grains of calaverite ($AuTe_2$), frohbergite ($FeTe_2$), coloradoite ($HgTe$), and altaite ($PbTe$).

The gold-bearing quartz veins are commonly accompanied by felsic dykes, whose orientations are controlled by shear zones. The dykes were previously interpreted to be emplaced before the development of shear zones and genetically unrelated to the quartz veins. New observations suggest, however, that felsic dykes and quartz veins are coeval.

Fluid inclusions from auriferous quartz and quartz-feldspar veins include carbonic, aqueous, and aqueous + carbonic types. The melting temperatures of the carbonic phases ranged from -60.9° to -57.8°C, indicating CO_2 dominance and presence of other gases such as CH_4 and N_2. Relatively high-homogenization temperatures (366° to 386°C) are found for fluid inclusions in quartz associated with K-feldspar. Isochores of paired liquid-rich and vapour-rich aqueous-carbonic fluid inclusions with homogenization temperatures of 366° to 373°C yield pressure values of 1.1 to 1.2 kbar, whereas isochores of carbonic inclusions indicate a much wider pressure range for the same temperature range, from 1.2 to 2.5 kbar. The pressure range may be related to fluid pressure fluctuation between lithostatic and hydrostatic conditions at a depth of about 9.6 km. The fluid composition, temperature, and pressure data are compatible with orogenic-type gold deposits.

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Golden Band Resources Inc. Plans to be the Next Gold Producer in Saskatchewan

Ronald K. Netolitzky [1], Klaus Lehnert-Thiel [1], and Rodney Orr [1]

Abstract

You may be surprised to learn that Golden Band has been exploring the La Ronge gold belt for over a decade. Our activities were largely overshadowed, however, by the high-tech boom, the parallel crash in the junior mining sector, poor gold prices, and by the diamond exploration craze. All of these made it very difficult to raise money or attract attention to a commodity which has been central to humanity for the past 8000 years. Nonetheless, Golden Band's strategy during these quiet years has been to build up a unique expertise in gold exploration and to assemble the predominant land position in this mature, but still very prospective, gold belt. As a result, Golden Band has created a portfolio worthy of an intermediate mining company and is at a position where it can start to transform itself from a junior exploration company to an emerging gold producer.

Golden Band now has over 73 500 ha under disposition, much of it acquired by simply staking orphaned claims. The balance was strategically acquired from companies like Golden Rule Resources, COGEMA, and Cameco who were no longer actively exploring by trading shares in Golden Band Resources for their properties with gold deposits. Another significant asset of Golden Band, also obtained with the acquisition of the claims, is the entire exploration database of these companies. Some 60 million dollars were collectively spent by industry in the La Ronge gold belt during the past 40 years.

Golden Band has both short-term and long-term business plans. The near-term plan is to restart gold production at its 100%-owned, 350 tonne/day Jolu gold mill with ore from the Bingo deposit which is located just north of the Churchill River, 50 road kilometres south of the Jolu mill. To this end, Golden Band has applied for an underground exploration permit from Saskatchewan Environment. This underground exploration work is required to confirm grade (in the +10g gold/tonne range) and continuity of the gold mineralization.

The long-term business plan is to construct a large, central mill in the Tower Lake area with a capacity of at least 2000 tonnes/day. The mill feed would derive from Golden Band's gold deposits located along the Byers Fault. Typically they have grades ranging between 2 and 5 g gold/t and can likely be mined by open pit (e.g., Tower Lake, Memorial, Komis, and Golden Heart). To date, the cumulative gold resources are approaching the one million ounce mark. Ongoing exploration drilling in the 2004-2005 winter program is expected to significantly increase this number. To this end, a scoping study has been commissioned to examine the economic viability of Golden Band's plans for the development of these deposits.

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Technical Session 3: Western Churchill Metallogeny

Peter Lake Domain Project: Analytical Update and New Field Results from Northwest Reindeer Lake (NTS 64E-NE) [1]

Ralf O. Maxeiner [2], Jason Craven [3], Sheldon Modeland [4], Nicole Rayner [5], Ken Ford [5], and David Corrigan [5]

Abstract

A multidisciplinary project aimed at establishing a new geological framework for the Peter Lake Domain and investigating its economic potential was initiated in the summer of 2002. Bedrock mapping in 2004 focused on gabbroic complexes in the Zengle Lake–Mackenzie Lake–Crane Island (Reindeer Lake) area at the northeastern extent of the domain. Preliminary geochronological results from previously mapped gabbroic and granitic rocks of the Patterson Island area indicate a surprising Proterozoic age for the Patterson Island Pluton and for some gabbroic rocks previously interpreted as Archean. Preliminary analysis of a new multi-parameter airborne and ground geophysical survey reveals potential differences between these Archean and Proterozoic gabbros. Gabbroic rocks of the 2.56 Ga Swan River Complex have lower average K and eTh concentrations than those from the 1.91 Ga Porter Bay Complex. Based on limited geochemical data, analyses of gabbroic to monzodioritic rocks of the Porter Bay Complex have distinct negative Ti-anomalies on chondrite-normalized trace element diagrams.

Archean and Proterozoic gabbroic complexes are emplaced within the granitoid basement of the Hearne Province, which includes an Archean granodiorite-tonalite migmatite complex, 2.57 Ga megacrystic monzogranite, mafic volcanic rocks with interbedded oxide-facies banded iron formation, and a variety of other granitoid rocks and gneisses. The 2.56 Ga Swan River Complex includes gabbro, gabbronorite, leucogabbro, diorite, and minor ultramafic rocks. It is characterized, in part, by pegmatitic, taxitic, and ophitic textures. Well-preserved igneous layering and intrusion breccias with a variety of mafic xenoliths and autoliths occur locally. The 1.91 Ga Porter Bay Complex comprises gabbro, melagabbro, diorite, quartz diorite, pyroxenite, megacrystic monzodiorite, monzonite, gabbronorite, and anorthositic gabbro. In several exposures, it exhibits spectacular primary igneous features including rhythmic zebra layering and cross-bedding. Layering is generally better preserved than in the Swan River Complex. Dioritic, monzodioritic, and monzonitic components generally postdate the gabbroic rocks.

Gabbroic to dioritic rocks in the Peter Lake Domain cover an estimated area of about 600 km^2 and are reported to contain platinum group element (PGE) occurrences with up to several thousand parts per billion combined platinum, palladium, and gold. The Neoarchean Swan River Complex and the Paleoproterozoic Porter Bay Complex show abundant evidence of well layered cumulate rocks, pegmatitic textures, intrusion breccias, magma mingling, multiple intrusive events, and disseminated magmatic pyrrhotite-chalcopyrite accumulations. Both intrusive complexes have significant potential to host reef-type PGE occurrences. Many of the PGE occurrences in the Peter Lake Domain also feature elevated copper, nickel, and/or chromium concentrations. The Swan Lake Pt-Pd-Ni-Cu showing (SMDI 1896), located southwest of the Patterson Island area, is contained within gabbroic to pyroxenitic rocks of undetermined age. Mineralization consists of disseminated pyrrhotite-chalcopyrite and is interpreted as magmatic in origin.

Four ductile deformational events are preserved in rocks of the northwest Reindeer Lake area. D1 and D2 were Archean events, whereas D3 and D4 were Paleoproterozoic in age. Two metamorphic events have affected the Peter Lake Domain, an upper amphibolite to granulite facies event at ca. 2.55 Ga and an upper greenschist to lower amphibolite facies event during the Trans-Hudson orogeny between 1.81 and 1.80 Ga.

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[1] This project was in part funded by NRCan under the Targeted Geoscience Initiative (TGI-II) and Northern Resources Development Program.
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Peter Lake Domain Project: Quaternary Investigations in the Northwest Reindeer Lake Area (parts of NTS 64E-15 and -16)

J.E. Campbell [1]

Abstract

Quaternary geological investigations in the MacKenzie, Zengle, and Reindeer lakes area involved surficial mapping at 1:50 000 scale, recording ice-flow indicators, and a regional till sampling survey. The dominant ice-flow direction was to the south-southwest (205° to 210°), becoming more southwesterly (215° to 220°) towards the southern boundary of the map area. Two older regional ice flow directions are oriented at ~188° (175° to 195°) and 228° to 240°. Rare, faint striae sets trending 154° (two sets) and 295° (one set) were also recorded.

Drift cover is variable. The Crane Island area, is dominated by bedrock (approximately 60 to 80%) mantled by less than 2 m of discontinuous drift cover. The present-day landscape is controlled by the bedrock topography with little geomorphic expression of the glacial deposits. Westward, the drift thickens and is more extensive, with less than 10% bedrock exposure. The landscape is more subdued there and reflects both glacial geomorphic features and bedrock topography.

The dominant surficial sediments are till and organic deposits. Sand and gravel deposits are associated with esker systems, minor meltwater drainage channels, stagnant ice hummocky moraines, and glaciolacustrine littoral deposits. Till occurs primarily as ground moraine veneer, less than 2 m thick, and ground moraine plain, greater than 2 m thick, as well as, hummocky moraine and stagnant ice moraine. Ridged moraine and streamlined forms such as drumlins and crag and tails are less common. Till composition varies with the type of deposit, thickness, and source rocks from which it is derived. At least four facies were identified: a silty-sand to sandy till, a very sandy till, a silty-sand matrix-rich diamicton, and a gravelly sand diamicton.

Winnowed and reworked sediments and raised strandlines, such as sand and cobble beaches, terraces, wave-cut notches, and ice-contact deltas indicate that glacial Lake Agassiz extended further north and west than previously thought. The highest strandlines were found at about 425 to 430 m asl. Much of the area below ~350 m asl is characterized by exposed outcrop, boulder lags, and winnowed till.

Several large southwest-trending subglacial meltwater drainage systems cross, or terminate, in the map area. These systems consist of subglacial tunnel valleys and/or esker complexes, and associated ice-contact deposits including ice-contact deltas.

A large part of the area is not suitable for drift prospecting, as bedrock, organic, ice marginal, and wave-reworked deposits dominate the terrain. Drift prospecting techniques are more applicable in the MacKenzie-Zengle lakes area where the drift cover is more extensive.

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New Multisensor (Gamma-ray Spectrometric, and Magnetic) Airborne Geophysical Surveys – Peter Lake and Wollaston Domains, 2004 – Status Report

K.L. Ford [1], J.M. Carson [1], R. Dumont [1], R.B.K. Shives [1]

Abstract

Ongoing collaboration between Saskatchewan Industry and Resources (SIR) and the Geological Survey of Canada (GSC) through its Northern Resources Development Program, is generating new multisensor (gamma-ray spectrometric and magnetic) geophysical data for areas of mineral potential in the Precambrian Shield of northern Saskatchewan. The resulting new surveys support a new geoscience infrastructure including improved framework geological mapping and better mineral exploration strategies.

On July 14, 2004, Fugro Airborne Surveys of Saint-Laurent, Quebec continued with a high-resolution fixed-wing airborne gamma-ray spectrometric and total field magnetic survey over portions of the Peter Lake and Wollaston domains covering parts of NTS map sheets 64E, 64L, and 74H. The Peter Lake portion of this survey was initiated in 2003, but suspended due to poor weather conditions. Funding for the airborne geophysical survey was provided through the government of Saskatchewan's Mineral Exploration Incentive Program. The survey was designed cooperatively by SIR and GSC. The GSC's Radiation Geophysics and Regional Geophysics Sections in Ottawa, under the Northern Resources Development Program, provided contract supervision and quality control to national NATGAM standards.

The new survey comprises 57 765 line kilometres along northwest-southeast–oriented flight lines spaced 400 m apart and northeast-southwest–oriented magnetic control lines spaced 4000 m apart. Sensors included a large-volume gamma-ray spectrometric detector (NaI, 50 litres downward and 8 litres upward looking) sampling every one second, and a caesium vapour magnetometer sampling 10 times per second. Data acquisition was completed on September 29, 2004. This new data provides improved geophysical and geochemical information that will enhance understanding of tectonic and metallogenic aspects of Archean terrane along the boundary of the Trans-Hudson Orogen, where significant platinum group mineral (PGM) potential exists within ultramafic complexes.

During an 11-day visit to the 2004 SIR field camp located on Spider Island, ground gamma-ray spectrometric, scintillometer and magnetic susceptibility measurements were collected at 320 sites. The majority of bedrock lithologies present within the Peter Lake Domain were measured. Average potassium (K) and equivalent thorium (eTh) concentrations range from 0.2 % and 0.5 ppm respectively for ultramafic units in the Patterson Island area, to 4.1 % and 23.8 ppm respectively for granitic to syenogranitic units in the Spider Island area. In addition to these ground studies, mapping activities by SIR staff included magnetic susceptibility and total radioactivity measurements.

Measurements on gabbroic rocks from the Patterson Island area indicate two different radioactive element signatures. The older (2562 Ma) Warner Lake gabbroic suite has average K and eTh concentrations of 0.5 pct and 1.4 ppm, respectively. Gabbroic rocks from the younger (1917 Ma) Porter Bay Complex have average K and eTh concentrations of 1.9 pct and 4.1 ppm, respectively, very similar to mineralized host gabbroic/monzonitic rocks at the Antoine Showing, which average 1.9 pct K and 3.4 ppm eTh. This apparent difference between barren and mineralized units offers exploration significance and may be recognizable in the airborne data. Additional ground truthing and airborne data analysis are required to verify these findings.

Interpretation of airborne gamma-ray spectrometric data requires an understanding of the radioactive element signatures of the different surficial deposits of the survey area and their relationship to the underlying bedrock units. Within the 2004, SIR map area sites were selected where multiple in situ spectrometric measurements were taken on bedrock and adjacent surficial material. Average K and eTh concentrations for the bedrock measurements range between 0.5 and 4.5 pct K, and 1.1 and 19.1 ppm eTh. Average K and eTh concentrations for adjacent surficial deposits range between 2.1 and 3.1 pct K, and 8.3 and 13.6 ppm eTh. Additional combined bedrock and surficial measurement sites are required to determine the regional significance of these signatures.

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Hands Across the Border: A Preliminary Tectonostratigraphic Framework for the Western Churchill Province in Saskatchewan, Nunavut, and the Northwest Territories

Sally Pehrsson [1], Ken Ashton [2], Colin Card [2], Charlie Harper [2], and the Western Churchill Metallogeny Project Team

Abstract

The western Churchill Province (WCP) spans the northern reaches of Manitoba, Saskatchewan (SK), and Alberta, and much of Nunavut (NT) and the Northwest Territories (NWT), yet remains the most poorly known region of the Canadian Shield. First broadly explored by helicopter reconnaissance programs of the 1950s and 1960s, it was defined by Stockwell (1962) as a province of Archean and Paleoproterozoic domains that had been severely deformed and metamorphosed during the Hudsonian (Trans-Hudsonian) orogeny. Hoffman's 1990 subdivision of the Churchill into the Archean Rae and Hearne Provinces, separated by the Snowbird Tectonic Zone (STZ), remains the state of understanding for significant parts of NT and NWT, whereas subdivision of northern SK has advanced significantly in the past 15 years.

The Western Churchill Metallogeny project, through its provincial and territorial partnerships, aims to update the tectonostratigraphic framework of the WCP and synthesize its regional metallogeny. Preliminary bedrock compilation and correlation between NT, NWT, and northern SK forms the basis for new working models of its regional makeup, with attendant implications for metallogeny. Key developments include:

1) *subdivision of the Rae province into distinct northeast-trending Meso-Neoarchean crustal domains that were potentially amalgamated during a latest Archean ca. 2.55 orogenic event;*
2) *delineation of an old Southern Hearne Domain in southern NT and northern SK characterized by local. 3.0 to 3.1 Ga Mesoarchean basement, widespread 3.0 Ga inheritance, and 3.0 to 3.2 Ga crust formation ages;*
3) *possible extension of nickel-PGE-prospective high Mg mafic and ultramafic rocks of Rankin-Ennadai belt into northeastern SK, as part of the distinct central-Southern Hearne Domain;*
4) *revised regional stratigraphic and metallogenic correlations for the Paleoproterozoic sedimentary sequences; and*
5) *possible correlation of the Dodge Domain of northern SK with the Wholdaia Domain of southern NWT, the site of the mafic cumulate-hosted Tha Lake Ni-Cu deposit.*

A new Paleoproterozoic crustal architecture is proposed. A regional, high pressure (>8 to 12 kbar), upper amphibolite to granulite crustal block has been identified that extends from SK to Southampton Island. Preliminary data suggest it experienced ca. 1.9 Ga tectonometamorphism, but also locally records an earlier 2.5 Ga event. The Legs Lake Shear Zone in SK, and the Tulemalu Fault Zone and Big Lake Shear Zone in NT form its southeastern margin, whereas the Chesterfield Fault Zone in NT forms its northern boundary. The Snowbird Tectonic Zone high-pressure granulite facies domains (10 to 2 kbar), including the Tantato, Selwyn, and Three Esker domains and the Kramanituar, Uvauk, Daly Bay, Thirty Mile, and P.O. Lake complexes, are localized along its southeast margin. A genetic link has been proposed between latest Archean to Paleoproterozoic movement of this major boundary and Ni-PGE-bearing anorthositic-mafic-ultramafic intrusions.

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Progress Report on U-Pb SHRIMP Zircon Geochronology and Sm-Nd Isotope Geochemistry of the Phelps Lake Area, Northeast Saskatchewan

C.T. Harper [1] and O. van Breemen [2]

Abstract

New U-Pb SHRIMP zircon ages and Sm-Nd isotope geochemical data has been obtained for five of seven samples from the Phelps Lake area in northeast Saskatchewan. The Phelps Lake area (NTS map sheet 64M) lies mainly in the Archean dominated northern Mudjatik Domain of the Hearne Province. Samples include Archean rocks, specifically tonalite orthogneiss from a migmatite complex, well-foliated tonalite and granite, and amphibolite, as well as Paleoproterozoic diatexitic granodiorite. The tonalite orthogneiss yielded an igneous crystallization age of 2714 ± 6 Ma, but showed no indication of older Mesoarchean inheritance. It had an εNd value at the time of emplacement of +2.07 with a TDM model age of 2.85 Ga. The foliated tonalite gneiss, typical of tonalites that intruded the migmatite complex and mafic volcanic rocks of the Ennadai Greenstone Belt (EGB) gave an igneous crystallization age of 2698 ± 6 Ma, with no indication of older inheritance in the zircon population. This tonalite had an emplacement εNd of +1.43 and a TDM model age of 2.88 Ga. These two tonalites may be part of a prolonged ca. 2.72 to 2.70 Ga magmatic event possibly correlative with early volcanism in the EGB. The foliated granite dyke, typical of granites that intruded the tonalite gneisses and apparently axial planar to isoclinal folds in the migmatite, yielded a crystallization age of 2680 ± 4 Ma, which is identical to dated rhyolites in the EGB. The granite also contains a significant inherited zircon population; some in the 2726 to 2693 Ma range derived from the dated tonalitic orthogneiss and some in the 2.99 to 2.90 Ga range indicate the existence of older Mesoarchean basement. The granite has an emplacement εNd of -0.48 and a TDM model age 3.0 Ga that provides further evidence of crustal melting and presence of Mesoarchean basement at the time of granite emplacement. The amphibolite gneiss yielded an age of 1830 ± 12 Ma as the timing of high-grade metamorphism, which is also coincident with the peak of Hudson granite emplacement in the Western Churchill Province. The diatexitic granodiorite, derived from the melting of older tonalite gneiss and amphibolite, yielded a crystallization age of 1812 ± 4 Ma. Inherited Archean ages range from 2565 to 2761 Ma, reflecting the source terrain and possible disturbance of the older zircons by younger thermotectonism. The εNd value at the time of emplacement was -10.74 and its TDM model age is 3.09 Ga clearly indicating its Archean crustal parentage.

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Geology of the Snowbird Lake Area and Implications for the Snowbird Tectonic Zone

Edith Martel [1]

Abstract

The Snowbird Lake mapping project is located in southeastern corner of the Northwest Territories, adjacent to the Nunavut and Saskatchewan borders. It is a multidisciplinary study initiated by the NWT Geoscience office in collaboration with the Western Churchill Metallogeny Project of the Geological Survey of Canada. The study area covers the Selwyn lozenge, the central of three lozenges entrained in crustal-scale shear zones. These shear zones partly define the Snowbird Tectonic Zone, which is thought to represent the boundary between the Rae and Hearne domains of the Churchill Province. Components of the study include remote predictive mapping, bedrock mapping, geochemistry and geochronology, surficial mapping, an aeromagnetic survey, and esker and till sampling.

The Selwyn lozenge consist mainly of granulite-grade orthogneiss (orthopyroxene+clinopyroxene+garnet± magnetite-bearing), upper amphibolite- to granulite-grade metasedimentary rocks (garnet+biotite+sillimanite± melt± cordierite(?)-bearing) and lesser amounts of mafic volcanic rocks (clinopyroxene+orthopyroxene+garnet-bearing), and previously unrecognized sequences of banded iron formation (BIF). The eastern margin of the Selwyn Lozenge is marked by the Striding mylonite zone, which juxtaposes the Selwyn Lozenge with a highly strained, granulite-grade plutonic panel. This panel consists of Chipman tonalite (ca. 3.0 Ga) and spatially related Chipman dykes (ca. 1.9 Ga) that were previously mapped as mixed metavolcanic and metasedimentary rocks. The presence of high-grade orthogneiss (Chipman tonalite and dykes) east of the Striding mylonite zone indicate that the zone itself does not define the boundary between the Rae and Hearne domains as previously suggested.

A change from granulite/upper amphibolite-grade orthogneiss to greenschist-grade supracrustal rocks (Hearne Domain) is located along an unexposed curvilinear, geophysically defined structure 20 km east of the Striding mylonite zone. This structure appears to define the western extent of greenschist-grade rocks of the Hearne Domain within the study area. Based on geometrical and lithological similarities with the Athabasca mylonite triangle, this structure is interpreted to represent the northern continuation of the Legs Lake Shear Zone in Saskatchewan. The Legs Lake Shear Zone juxtaposes high-pressure granulite rocks with low-pressure amphibolite rocks of the Hearne Domain.

Proterozoic rocks include a sequence of limestone and dolostone, granitic plutons, and northwesterly oriented Mackenzie diabase dykes. The extent of rocks previously assigned to the Proterozoic Hurwitz Group is questioned and a sequence of volcanic rocks (and associated BIF) has been sampled for geochronology to test if they are Archean.

The structural history of the rocks in the lozenge is complex; the earliest structures preserved are a composite gneissosity (Sgn)/foliation (S1) with a moderate dip and a northwesterly oriented enveloping surface, along with recumbent, isoclinal folds (F1). D1 structures are folded by northeast-southwest–trending folds (F2) with an axial planar foliation (S2), producing large-scale fold interference patterns (F1/F2). A mylonitic fabric concentrated along northeast to easterly oriented shear zones, overprints the Chipman dykes. This fabric is interpreted to be correlative with the northeast oriented fabric observed across the study area.

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Two Billion Years of Crustal Reworking Recorded in the Beaverlodge Belt of Northwestern Saskatchewan: Summary of Results and Implications for Mineral Exploration

R.P. Hartlaub [1], L.M. Heaman [1], K.E. Ashton [2], T. Chacko [1], A. Simonetti [1], and R.A. Creaser [1]

Abstract

The economic importance of the Beaverlodge Belt near Uranium City, Saskatchewan, has stimulated a geological reassessment of the region north of Lake Athabasca. This geological reassessment, which commenced in 1998 with detailed 1:20 000 scale field mapping and sample collection, has included the examination of more than 4000 outcrops in the region. Geochemical and geochronological study of samples has, to date, included: ~110 TIMS U-Pb analyses of zircon, titanite, monazite, and baddeleyite; >150 Laser Ablation U-Pb zircon analyses; >400 electron microprobe U-Pb monazite chemical dates; >40 Lu-Hf and >25 Sm-Nd isotopic tracer analyses; and >150 whole-rock geochemical analyses. Our large data set for the area has helped us to identify and better constrain a complex Precambrian history that spans more than two billion years.

The oldest exposed rocks in the region are isotopically juvenile ca. 3.0 Ga granites. These basement granites are overlain by several sedimentary basins, the oldest of which contains complexly deformed and metamorphosed quartzite, pelite, iron-formation, and carbonate rocks of the Murmac Bay Group. Circa 2.3 Ga felsic volcanic clasts characterize the basal conglomerate at the contact between ca. 3.0 Ga basement and Murmac Bay group quartzite. Detrital zircons from these quartzites and psammites are dominantly Paleoarchean in age (3.6 to 3.93 Ga), hinting at an ancient component to the Rae Province. Three pulses of felsic magmatism at ca. 2.6 to 2.63 Ga, 2.28 to 2.32 Ga, and 1.93 to 1.97 Ga are recognized. The two younger pulses are coeval with widespread high-grade metamorphism and deformation. The youngest pulse of granite (1.93 to 1.97 Ga) is leucocratic and crustally derived. A crustal derivation is consistent with the sequestering of gold in the economically important Box Mine granite.

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Geology of the 1:250 000-scale 74N Tazin Lake Map Sheet: A Progress Report

K.E. Ashton [1] and W.L. Slimmon [1]

Abstract

Compilation of the Tazin Lake map sheet has been initiated with the stitching together of previous 1"=1 mile geological maps, mainly dating from the 1950s and 1960s. Recent 1:20 000-scale re-mapping in the southeast, along with a regional airborne magnetic-radiometric survey completed in 2000, is being used to re-interpret many lithological units. The result is a map dominated by igneous rocks and derived orthogneisses that underwent upper amphibolite to granulite facies metamorphism at about 1.90 Ga, upon which several subsequent supracrustal successions have been unconformably deposited.

The Beaverlodge, Zemlak, and Ena domains together appear to have a shared geological history. Pre-1.9 Ga gneisses include 3.0 and 2.64 Ga granitoids with arc-type geochemical affinities, together with 2.3 and 1.9 Ga granitoids exhibiting syn- to post-collisional attributes. The Murmac Bay Group, a rift-type, dominantly siliciclastic succession, has yielded abundant Paleo- to Mesoarchean detrital zircons, but is temporally constrained by 2.33 Ga detritus in its basal conglomerate, along with an identical age from a granite intrusion. The age and origin of more widespread pelitic gneisses and derived diatexites that lack the characteristic quartzite-basalt association of the Murmac Bay Group are uncertain. Post-1.9 Ga supracrustal successions include the greenschist facies Thluicho Lake Group, a fining-upward, siliciclastic succession that was deposited between 1.90 and 1.82 Ga, and may be correlative with the Nonacho Group in the Northwest Territories. The Martin Group redbed-basalt succession unconformably overlies the Thluicho Lake Group and was being deposited at 1.82 Ga. It is considered broadly correlative with the lower Dubawnt Supergroup in Nunavut.

The Train Lake Domain in the easternmost part of the map sheet also appears to be dominated by orthogneisses that have yielded poorly constrained 2.58 and 2.54 Ga ages farther east, but also includes pelitic and intermediate to mafic volcanic supracrustal remnants, and abundant, late Hudson-type granite.

The Nolan Domain is dominated by 2.64 to 2.60 Ga granodioritic to dioritic granitoids that together resemble a continental arc. Its boundary with the Zemlak Domain is gradational and may represent more of a deformational front than a lithological break.

The Taltson Domain is similarly made up of granodioritic to dioritic rocks, but of 1.97 to 1.96 Ga age, based on work in Alberta. They are continental arc rocks of the Taltson Magmatic Zone that were emplaced due to terrane accretion at the western Rae craton margin. The greenschist facies Waugh Lake Group has been interpreted as an intra-arc basin based on the bracketing of its deposition between 2.02 and 1.97 Ga.

The Athabasca Basin dominates the southern part of the map sheet.

Known mineral deposits include the extensive uranium mineralization associated with the Athabasca and Martin groups, gold in the Beaverlodge Domain (e.g., Box Mine), Cu-Pb-Ag mineralization apparently associated with the Thluicho Lake and Waugh Lake groups, as well as the Hill Island Assemblage, and rare earth element-rich veins in the northwest, along strike from those at Hoidas Lake.

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Investigations of the Thluicho Lake Group: A Stratigraphic, Structural, and Tectonic Perspective (Uranium City Project)

R.C. Hunter [1], K.M. Bethune [1], G.M. Yeo [2], and K.E. Ashton [2]

Abstract

The Thluicho Lake Group is a greenschist-facies clastic succession in the Zemlak Domain of the southwestern Rae Province. It consists of a single, upward-fining succession of conglomerate, pebbly arkose, arkose, and argillite. The contact between the basal conglomerate and the mylonitic basement, though locally strained, is elsewhere a 'stitched' angular unconformity. This indicates that the Thluicho Lake Group is essentially autochthonous. Two informal formations are recognized: the "Powder Lake Formation", which comprises the "Gulo Lake" conglomerate, the "Camel Lake" pebbly arkose, and the "Wellington Lake" arkose members; and the "Camsell Portage Formation", which comprises the "Falls" silty arkose, the "Waterloo Lake" arkose and argillite, and the "Slate Island" argillite members.

Three phases of folding have affected the Thluicho Lake Group, including: 1) isoclinal F1 folds; 2) steeply inclined, northeast-trending, open to close F2 folds; and 3) upright, north-trending, open F3 folds. This multiple folding was followed by brittle faulting. Major fault sets include: 1) dextral, northeast-striking faults; 2) south-southeast–striking faults with dip-slip, sinistral displacement; and 3) east-striking extensional fractures and normal faults. Interference between F1 and F2 folds resulted in a superposed folding pattern intermediate between type II and type III end members, though closer to type II overall. The regional fold pattern is further complicated by the various orientations of brittle faults. Investigation of the Ellis Bay Formation has shown that it represents strongly brecciated Thluicho Lake and Martin group strata rather than a discrete stratigraphic unit. The deposition of the Thluicho Lake Group, together with the first two phases of folding, is constrained between 1.90 Ga, an upper amphibolite-facies metamorphic event that pre-dated deposition of the Thluicho Lake Group, and 1.82 Ga, which represents the age of diabase dyke intrusion and deposition of the Martin Group. The deposition of the Martin Group pre-dated F3 folds, suggesting that F3 folding likely resulted from east-west shortening related to the Slave Province Indenter and terminal collision in the Trans-Hudson orogeny.

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Black Bay Shear Zone Transect: Framework Data Across the Hoidas-Nisikkatch Rare-Element Trend, Northwest Saskatchewan

M.H. Gunning [1] *and C.D. Card* [2]

Abstract

Framework data from soil and rock geochemistry, magnetic-susceptibility mapping, and gamma-ray spectrometry, were obtained from two transects across the Black Bay Shear Zone, and associated rare-element showings. There are 26 reported rare-element showings in a 10-km-long, northeast-trending belt between Hoidas and Nisikkatch lakes. The showings comprised clinopyroxene-bearing dykes with rare-element-bearing allanite and apatite clots. The light rare-earth elements cerium, neodymium, and lanthanum are most enriched, along with the rare-elements yttrium and thorium. Rare-element concentrations vary relative to the abundances of allanite and apatite, which contain inclusions of thorite and monazite.

There are three key conclusions from this work:

1) ***The rare-element dykes are magmatic**. They are associated with granite pegmatite dykes, and are correlated with Cerny's* Abyssal Class *of rare-element pegmatites. Most showings contain late-stage veinlets, but lack broad alteration envelopes.*

2) ***Soil geochemistry and gamma-ray spectrometry work as exploration tools**. Anomalies are extreme, but also very tight (no shoulders). Thorium and uranium are both elevated in gamma-ray spectrometer data, but thorium is much higher overall. The elements cerium, lanthanum, and thorium are the strongest geochemical pathfinders in soil.*

3) *The Black Bay Shear Zone is regionally prospective as the overall **trap**; dilational zones slightly oblique to the main structural grain accommodated granite emplacement. The Train Lake Domain is regionally prospective as the metal **source**. It contains biotite granite and granite pegmatite dykes highly enriched in all of the key elements of the showings. Granite pegmatites are likely an evolved end-member of a regional granitic magmatic event.*

A detailed report for this project will be released as Saskatchewan Industry and Resources Open File Report 2004-2, in early 2005.

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Technical Session 4: Saskatchewan Diamonds

Preliminary Investigation: Sedimentology and Provenance of the Wood Mountain Formation and Derived Glacial and Glaciofluvial Sediments – Context for Kimberlite Indicator Mineral Anomalies

Lynn Kelley [1] *and Gary Yeo* [1]

Abstract

Garnet, diopside, and chromite with chemistries inferred to indicate mantle affinity are geochemical pathfinders exploited in prospecting for diamond. In southern Saskatchewan, these minerals are found in high abundances in gravel, sand, and poorly-consolidated conglomerate of the Wood Mountain Formation, and overlying tills and glaciofluvial deposits. Several campaigns have been mounted to explore for a potential kimberlitic source for these pathfinder minerals, but no satisfactory explanation for their presence has been put forward. This project is intended to provide geological context for the occurrences of kimberlite indicator minerals found in the Wood Mountain area, by examining the transport history and provenance of the strata containing them. This note summarizes preliminary observations on sediment transport data and sediment provenance from seven locations. Grain size analysis, detailed provenance studies, and analysis for kimberlite indicator minerals and detrital gold are pending, and will be reported upon in a future communication.

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Cr-diopside (Clinopyroxene) as a Kimberlite Indicator Mineral for Diamond Exploration in Glaciated Terrains

David Quirt [1]

Abstract

For diamond exploration in glaciated terrains, Kimberlite Indicator Minerals (KIMs) are those minerals, contained in glacial deposits, that are characteristic of kimberlite, the dominant host for diamonds. As KIMs are many times more numerous in the kimberlite host rock than are diamonds, they are an important pathfinder for kimberlites. Typical KIMs include garnet, pyroxene, Cr-spinel, Mg-ilmenite, and olivine. Interpretation of the chemistry of KIM grains, such as clinopyroxene, allows evaluation of the kimberlitic affinities of the grains and delineation of possible glacial dispersion trains suggestive of potentially diamondiferous kimberlite sources. Pyroxenes from both peridotitic and eclogitic mantle sources can be KIMs, with clinopyroxene (cpx) being a common groundmass mineral in kimberlite.

There have been two historical interpretative problems, however, with the use of cpx as a KIM. Firstly, the colour criteria used in picking KIM cpx (e.g., Cr-diopside) appear to vary widely between individual microscopists; and secondly, problems can arise from the presence of non-kimberlitic (alkalic gabbro, basalt, komatiite, syenite, carbonatite, ultrapotassic volcanic) Cr-diopsides in the glacial deposit sampled.

Given the wide range of cpx host environments, determination of suitable cpx compositions for use in KIM evaluation and pyroxene thermobarometry is important. The chemical data should be constrained to compositions similar to those determined for kimberlitic cpx and diamond inclusion (DI) cpx worldwide. Kimberlitic cpx from peridotitic sources are typically diopsidic or, to a lesser extent, calcic/non-ferrous augitic on a Wo-En-Fs diagram; as are many cpx grains of crustal origin, most eclogitic (low-Cr) DI cpx, and many 'eclogitic' non-DI cpx. Consequently, the data must be screened for peridotitic cpx, permitting evaluation of only those grains having the selected criteria: diopsidic to calcic/non-ferrous augitic compositions ($27.5\% < Wo < 55\%$ and $En/(En+Fs) > 0.5$) and low-Na content ($J < 0.5$). Screening for high-Na DI eclogitic cpx uses the same Wo-En-Fs criteria as for peridotitic cpx, plus the selected criteria: Cr content $< 0.5\%$ Cr_2O_3 and $J > 0.5$ (i.e., cation $Na > 0.25$).

Several large kimberlite/diamond indicator mineral data sets were examined for pyroxene chemical trends. The entries of Fe, Al, Na, Ca, and Cr into the cpx structure are strongly affected by the P-T-X conditions during mineral crystallization, so multidimensional diagrams of cpx atomic cation proportions are used to illustrate the chemical variation of mantle-derived kimberlite cpx relative to the more Fe-rich non-kimberlitic (crustal) grains typically present in glacial deposits. Antipathic Fe-Cr, Fe-Na, Al-Cr, and Al-Na data trends present in four-dimensional data plots can be used to discriminate between 'deeper mantle-derived' grains and 'more crustal' grains. These interpretive guides provide useful discriminations between kimberlitic and non-kimberlitic peridotitic cpx in a suite of cpx KIM chemical data from samples of glacial deposits.

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Update on Kimberlite Eruptive Sequences, Volcanic Stratigraphy, and Three-Dimensional Modeling of the 140/141 Kimberlite Complex, Fort à la Corne Field, Saskatchewan

S.E. Harvey [1], B.A. Kjarsgaard [2], J-P. Zonneveld [3], and D.H. McNeil [3]

Abstract

Detailed studies of 31 drill cores were undertaken to define the 3-D architecture of the Fort à la Corne Joint Venture's 140/141 kimberlite body. Data derived from over 350 whole rock major- and trace-element geochemical analyses, 205 micropaleontology samples for biostratigraphic age assignments, and various geophysical techniques (e.g., magnetic susceptibility, 2-D seismic imaging, and borehole geophysics) were utilized in conjunction with macroscopic core observation to produce detailed drill core logs.

Kimberlite pyroclastic subaerial and marine fall deposits and volcaniclastic pyroclastic flow deposits, mass slumps, and debris flows are interstratified with continental to marine sediments of the Cretaceous Mannville Group (Cantuar and Pense formations) and Lower Colorado Group (Joli Fou, Viking, and Westgate formations) in the Fort à la Corne kimberlite field of east-central Saskatchewan. In detail, seven main kimberlite phases, some of which include multiple facies, such as kimberlite breccias and resedimented kimberlite, have been characterized. Feeder vents, aligned in a distinct northwest linear trend, have been identified for five of the phases.

The oldest kimberlite phase is interstratified with continental sediments of the upper Cantuar Formation and, as such, is considered Cantuar-age equivalent. Three Pense Formation age-equivalent kimberlite phases comprise a volumetrically significant component of the 140/141 kimberlite complex. One of the phases had a positive relief of about 85 m. Marginal marine to marine sediments of the Joli Fou Formation are interstratified with two kimberlite phases that are also volumetrically important. The youngest kimberlite phase lies at the top of the upper Joli Formation shale and is overlain by marine shale of the Westgate Formation. Thus, it is interpreted as Viking-age equivalent. The multi-phase composite 140/141 kimberlite body records periodic kimberlite volcanism over a period of at least three million years and potentially as long as 6 million years.

Detailed core logs have been utilized to construct 2-D cross sections which in turn have been used to prepare a 3-D digital model of the 140/141 kimberlite complex. This model may provide important insight into the relationship between the various kimberlite phases and diamond distribution.

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Overview of the Fort à la Corne Joint Venture Program for 2004

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Abstract not available at time of printing

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Geology of the Star Kimberlite, Saskatchewan

B.A. Kjarsgaard [1], S. Harvey [2], J-P. Zonneveld [3], D. McNeil [3], L. Heaman [4], and D. White [1]

Abstract

Thirty-two drill cores containing kimberlite and Cretaceous and Devonian sedimentary rocks from the diamondiferous Star kimberlite in the southeast part of the Fort à la Corne kimberlite field, central Saskatchewan have been investigated over the past three years. Integration of all available data, including detailed core logs, whole rock major- and trace-element geochemistry (>350 samples), U-Pb perovskite age determinations, and micropaleontologic age assignments formed the basis for the development of 2-D cross sections and a conceptual 3-D model for the Star kimberlite. On the basis of macroscopic appearance, geochemistry, volcanic bedding characteristics, stratigraphic position, and petrography, four distinct phases of kimberlite are recognized in the Star kimberlite body.

Cantuar-equivalent age kimberlite consists of medium-grained, matrix supported, subaerial pyroclastic fall deposits (and their fluvial reworked equivalents) of less than 10 m total thickness in siliciclastic sediments of the Cantuar Formation. Although individual kimberlite beds are 0.2 to 9.0 m thick, 1 to 2 m thick massive or fining-upwards beds are typical. Cantuar-equivalent age kimberlite occurs predominantly in the northwest part of the Star kimberlite and thins rapidly to the south and east.

Pense-equivalent age kimberlite consists of clast-supported, very coarse- to medium-grained pyroclastic fall deposits which conformably overlie shales or sandstones of the Pense Formation. Kimberlite is in beds 0.5 to 5.0 m thick, but 1 to 2 m thick beds are typical. Bedding types include massive, normal graded, and reverse-graded varieties. Mantle-derived xenocrysts are common in these olivine and juvenile lapilli-bearing tuffs. Pense-equivalent age kimberlite occurs over a wide area in the northern and northeastern parts of the Star kimberlite. Typical drill intersections vary from ~2 to 38 m thick. In a subset of drill holes on the northeastern part of the Star kimberlite, Pense-equivalent age kimberlite is conformably overlain by up to 12 m of slumps and mass flow deposits inferred to be sourced from Pense kimberlite. At present, the location of the feeder vent for the Pense-equivalent age kimberlite is unknown.

Early Joli Fou-equivalent age kimberlite consists of clast supported, very coarse- to coarse-grained pyroclastic fall deposits in normal graded beds 1 to 25 m thick, although 4 to 10 m thick beds are typical. Mantle derived xenocrysts and microxenoliths are common in these olivine crystal tuffs. Trends of increasing grain size and increasing total early Joli Fou-equivalent age kimberlite thickness indicate the source feeder vent was in the vicinity of the Star 16, 25, 26, 32 core holes, in the west-central part of the Star kimberlite. The crater rim of the early Joli Fou-equivalent age kimberlite formed a paleo-topographic high, which is still exceptionally well preserved, at about 35 m below the Cretaceous-Quaternary unconformity. Vent distal, extra-crater early Joli Fou-equivalent age kimberlite deposits conformably overlie shales of the lower Joli Fou Formation (Spinney Hill Member) as revealed in the Star 2, 5, 6, 8, 28 core holes, for example. The early Joli Fou-equivalent age kimberlite is the volumetrically dominant kimberlite phase in the Star kimberlite body. Post-deposition slumps and mass flow deposits into the early Joli Fou crater vary from less than 2 m to more than 20 m thick and were sourced from early Joli Fou-equivalent age kimberlite.

Late Joli Fou-equivalent age kimberlite consists of matrix supported, medium- to fine-grained volcaniclastic deposits and are found in the west-central and north-west part of the Star kimberlite body. Trends of increasing grain size and increasing total late Joli Fou-equivalent age kimberlite thickness indicate the source feeder vent was in the vicinity of the Star 20 core hole, in the extreme western part of the Star kimberlite body. Vent proximal late Joli Fou-equivalent age kimberlite which filled the early Joli Fou crater is normal or oscillatory graded, with beds typically 0.5 to 15 m thick. Late Joli Fou-equivalent age kimberlite deposited on top of or outside the early Joli Fou kimberlite crater rim is a single, massive, 5 to 15 m thick bed which shows a slight fining-upward sequence. These late Joli Fou-equivalent age kimberlite volcaniclastic deposits imperceptibly grade into 5 to 30 m thick slump and mass flow deposits, which were derived from late Joli Fou-equivalent age volcaniclastic kimberlite. The kimberlite and associated slump and mass flow deposits are conformably overlain by upper Joli Fou Formation and/or Viking Formation sediments, hence these kimberlites are considered late Joli Fou equivalent in age.

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The overall 3-D geometry of the Star kimberlite body was influenced by syn-volcanic faulting. In the west-central area of the Star kimberlite are syn-early Joli Fou-equivalent age faults, which have a maximum throw of 54 m and are inferred to form a ring-fault modified graben structure. The graben has preserved exceptionally thick (up to 100 m) sequences of early Joli Fou-equivalent age kimberlite pyroclastic airfall deposits. Typically, such thick intersections of pyroclastic airfalls from a single kimberlite type in the Fort à la Corne field are only associated with a feeder vent system, within a limited spatial area.

Local and Regional Stratigraphic Correlation as a Tool for Accurately Assessing the Depositional Geometry and Emplacement History of Fort à la Corne Kimberlites

J-P. Zonneveld [1], D.H. McNeil [1], B.A. Kjarsgaard [2], and S.E. Harvey [3]

Abstract

Vertically oriented, elongate, carrot-shaped diatremes are the most commonly described kimberlite bodies. Because kimberlite usually occurs in ancient cratonic settings dominated by prolonged erosional histories, pyroclastic kimberlite is rarely observed. Even the most complete examples described to date (i.e., M1 and Orapa, Botswana, and Mwadui, Tanzania) have experienced erosion, and pyroclastic rocks are limited to crater-fill deposits. Numerous (~70 to 75) diamond-bearing kimberlites occur in the Fort à la Corne region, east-central Saskatchewan. The Fort à la Corne kimberlites are exceptional in the relative completeness of the preservation of their volcanic edifices and extra-crater pyroclastic deposits. Variably shaped feeder pipes are associated with dominantly planar to tabular, variably extensive, horizontally bedded kimberlite aprons. Sheet- and mound-like kimberlite deposits from the Fort à la Corne area include the first well-described examples of extensive extra-crater primary airfall kimberlite. These extra-crater pyroclastic deposits occur interstratified with Lower Cretaceous (Albian and Cenomanian) marine, marginal marine, and continental sediments.

The complex nature of the Fort à la Corne kimberlite bodies necessitates utilization of tools from other disciplines, such as sedimentary geology, stratigraphy, palaeontology, radiometric age determinations, and whole-rock geochemistry to effectively characterize their nature, geometry, and emplacement history. Particularly important is the use of marker horizons to identify local structural deformation. Marker horizons utilized in Fort à la Corne investigations include specific facies (i.e., coal, shale horizons, thin pyroclastic kimberlite beds, regional bentonite beds, etc.) and specific lithostratigraphic units. The Pense Formation, a highly bioturbated, quartz-dominated sandstone interval bound by regional discontinuity surfaces is an example of the latter and has proven especially useful in the Fort à la Corne area.

The two kimberlite bodies analysed in detail (Star and 140/141) both exhibit evidence of significant local faulting. Many of these faults are related to initial kimberlite volcanism. However, differential compaction and subsidence of kimberlite and sedimentary host strata as well as to volume-changing mineralogical alteration (i.e., olivine→ serpentine+magnetite=volume increase of ~15 to 20%) are also important. Failure to identify faults could effectuate mis-correlation of genetic kimberlite units and possible errors in estimating diamond grades, which vary widely between genetic kimberlite units within a single kimberlite body. Disregarding the relationship of individual kimberlite units to specific marker horizons could result in erroneous mapping of original depositional geometry and could thus promote significant errors in kimberlite volume/tonnage calculations.

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Bulk Sampling the Star Kimberlite in Central Saskatchewan

G.H. Read [1], K.Y. Marcia [1], M. Shimell [2]

Abstract

Shore's 2004 Star Diamond Project underground bulk sampling program, which commenced in 2003, is designed to recover a parcel of at least 3000 carats of diamonds from the Star Kimberlite in order to enable an accurate valuation of a large parcel of diamonds that is representative of "run-of-mine" production. The Star Kimberlite is accessed via a 4.5 m diameter, concrete-lined vertical shaft, which has been sunk through 107 m of sedimentary/ glacial overburden and into the Star Kimberlite, to a depth of 250 m below surface. Shaft stations have been established at 175 m and 235 m below surface respectively, and an extensive network of lateral drifts has been established on the 235 m level. Up to 25 000 tonnes of kimberlite will be recovered from the shaft and drifts and processed on site to produce this diamond parcel.

Kimberlite material continues to be extracted from the 235 m level in 250 to 350 tonne batch samples. Individual kimberlite batch samples are processed through Shore's on-site diamond processing plant from which diamond concentrates are produced using a process that includes crushing, scrubbing, screening, dense media separation, X-ray sorting, and grease table recovery methods. The diamond concentrates recovered from the X-ray sorting and grease tabling are sent to SGS Lakefield Research Limited ("SGS Lakefield") in Lakefield, Ontario for final diamond recovery. All diamonds larger than 0.85 mm recovered by SGS Lakefield are individually weighed and described and the results reported to Shore Gold at regular intervals. Results obtained from the bulk sampling program to date have been disclosed by Shore via press releases which can be downloaded from both Shore's website (www.shoregold.com) or from SEDAR (www.sedar.com).

As of November 2004, some 23 000 tonnes of kimberlite has been extracted in individual sample batches that generally range in size from 250 to 350 tonnes. Diamond recovery has been completed from a total of 16 207 dry tonnes of kimberlite, leading to the recovery of 2120 carats (refer to Shore Press Release dated November 2, 2004). This processed kimberlite material includes some 8000 tonnes from the vertical shaft, with the balance from 175 m shaft station and the multiple lateral drifts located on the 235 m level. An additional 2393 dry tonnes of kimberlite (all from the 235 m level) has been processed through the diamond process plant with the ensuing diamond concentrates shipped to SGS Lakefield for final diamond recovery. The production rate of Shore's diamond processing plant was increased in early September 2004 so that the processing of all mined kimberlite can be completed as soon as possible after the anticipated completion of underground mining near the end of September 2004. Shore's diamond processing plant will run through November 2004 until the processing of all kimberlite is complete. Diamond recoveries at SGS Lakefield will also continue in November 2004 with anticipated parcel valuation by year-end.

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Abstracts for Other Papers Appearing in the Summary of Investigations 2004, Volume 2 (CD-ROM)

Geology of the Camsell Portage Area, Southern Zemlak Domain, Rae Province (Uranium City Project)

K.E. Ashton [1] and R.C. Hunter [2]

Abstract

The Camsell Portage area includes a variety of foliated to gneissic granitoid rocks of inferred Archean age, psammopelitic to pelitic gneisses and migmatites, and widespread leucogranites, all of which were subjected to upper amphibolite facies metamorphism at about 1.9 Ga and multiple deformational events prior to intense and widespread mylonitization. Following exhumation, this basement complex was unconformably overlain by the Thluicho Lake Group, a fining-upward conglomerate-arkose-argillite succession that was metamorphosed to greenschist facies and doubly folded prior to uplift, erosion, and deposition of the Martin Group redbeds. Deposition of the Martin Group was accompanied by widespread diabase dyke emplacement at about 1.82 Ga along dominantly east-west normal faults, and both were subjected to north-trending folds attributed to the Trans-Hudson Orogen.

A number of Cu-Pb-Ag±U showings are associated with the basal unconformity of the Thluicho Lake Group and the east-trending diabase dykes. The basin into which the Thluicho Lake Group was deposited appears to have originally been much larger, enhancing the potential for economic mineralization.

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A Field Description of the Myo Rhyolite, Flin Flon and Creighton, Saskatchewan

K.A. Bailey [1] *and H.L. Gibson* [1]

Abstract

The Flin Flon Mining Camp, in the Flin Flon Belt of the Paleoproterozoic Trans-Hudson Orogen, is host to three world-class volcanogenic massive sulphide ore bodies: the Flin Flon, Callinan, and 777 deposits. The deposits are hosted in the felsic rocks of the Millrock Member of the Flin Flon Formation, in the eastern limb of the Beaver Road anticline. The Myo Member, in the west limb of the Beaver Road anticline, is thought to be the time-stratigraphic equivalent of the Millrock Member and, thus, is of particular interest for its volcanogenic massive sulphide potential. The purpose of this project is to construct a stratigraphic and lithogeochemical comparison between the ore-hosting Millrock Member and presently barren Myo Member.

Initial findings for this study, based on the mapping of two 1:2000 scale stratigraphic sections are that the Myo Member comprises four types of rhyolite. The rhyolite types have a variety of facies including massive, flow banded, flow brecciated, and volcaniclastic. Locally, there appears to be a duplication of stratigraphy that suggests fault repetition.

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Overview of the Geochemistry of Archean and Proterozoic Rocks of the Phelps Lake Region, Mudjatik Domain, Hearne Province

C.T. Harper [1]

Abstract

Geochemical analyses of the major rock units from the Phelps Lake Project are reported and preliminary interpretations of the data presented. Archean tonalitic orthogneiss components of migmatites and gneissic tonalite intrusions are calcic, peraluminous rocks, with volcanic arc granite (VAG) affinity, high Sr/Y and La/Yb ratios, and a neutral to positive Eu anomaly. These are similar to the characteristics of Archean tonalite-trondhjemite-granodiorite suites that are thought to have formed through partial melting of a shallow subducting, garnet-bearing eclogitic, or basaltic crust. Archean granitic intrusions are calc-alkalic, peraluminous rocks with transitional VAG to syn-collisional granite (syn-COLG) affinities. The Archean Ennadai Group comprises mainly mafic with minor intermediate to felsic metavolcanic rocks and minor interlayered psammopelitic to pelitic schist and various iron formation facies. The mafic metavolcanic rocks are subalkaline, high-Fe to high-Mg tholeiites with transitional MORB to VAB character, which is typical of volcanic arc–back arc basin settings. The felsic metavolcanic rocks are calc-alkaline, and typical of a volcanic arc setting. The chemical signature of ten samples of various iron formation facies, particularly with a strong positive Eu anomaly, are similar to iron formations associated with volcanic-hosted massive sulphide deposits and suggests there may be potential for the Ennadai Group to host such deposits. Weakly to strongly iron sulphide-bearing (± chalcopyrite) metavolcanic rocks and mafic metavolcanic-hosted pyritic quartz veins, contain background to anomalous concentrations of base and precious metals.

Proterozoic-aged rocks include the Hurwitz Group metasedimentary rocks and various syn- to post–Trans-Hudson intrusions. Pelitic and ferruginous pelitic schists and associated iron formations of the Hurwitz Group have similar rare earth element profiles as the North American Shale Composite. The general negative Eu anomaly of the ferruginous pelites and iron formations is characteristic of shale/mudstone-hosted iron formations. Proterozoic intrusions are subdivided into two age groups: the 1.85 to 1.8 Ga Hudson and the 1.76 to 1.75 Ga Nueltin granite suites. Chemically, both suites are silicic, potassic, calc-alkaline, and peraluminous granites. They mostly have syn-COLG affinity. The Nueltin granites have a tendency to be porphyritic, fluorite-bearing, and possibly REE-enriched. Perhaps the most interesting sample collected is a massive, lepidolite pegmatite boulder that has very high concentrations of Li, Rb, Cs, Nb, Ta, Sn, Be, Tl, Ga, and Ge, which is characteristic of complex, rare element pegmatites of the Bernic Lake type. Such pegmatites form from volatile-rich magmas commonly associated with post-tectonic granitic intrusions. The fluoritic Nueltin granite suite is a likely candidate from which the rare element pegmatite could have originated, and thus the boulder's source may lie nearby to the north or northeast.

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Synthesis of Diamond Recoveries from the Fort à la Corne Kimberlite Field, East-central Saskatchewan

Shawn Harvey [1]

Abstract

The Fort à la Corne kimberlite field, 60 km east of Prince Albert, Saskatchewan, consists of 72 volcaniclastic-dominated "crater-facies", Cretaceous kimberlites. The kimberlites are highly variable in size, complexity, and diamond content. They vary from small, possibly mono-eruptive, kimberlites to very complex, typically large multi-phase kimberlites in which up to six eruptive phases have been recognized. Furthermore, each of those eruptive phases may consist of various facies. The largest kimberlite, at about 675 million tonnes, is comparable to some of the largest in the world. Since their initial discovery in 1988, over 75% of the kimberlites have proven to be diamondiferous and approximately 50% have returned macrodiamonds.

This paper presents a summary of microdiamond and macrodiamond data from the Fort à la Corne kimberlite field. The data are compiled from numerous non-confidential mineral assessment files, archived by Saskatchewan Industry and Resources, and news releases. These data will function as a baseline for future exploration, not only in the Fort à la Corne area, but elsewhere in the Province. Assessment of diamond potential, based on microdiamond counts and distributions coupled with macrodiamond recoveries, has revealed that parts of the Fort à la Corne kimberlite field appear more prospective than others. Furthermore, correlation between diamond distribution and kimberlite volcano-stratigraphy has demonstrated that diamond potential of the various kimberlite phases differs. This relationship is an important parameter in the assessment of economic feasibility of the kimberlites.

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Notes

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